

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Dike

(Feet)

Code 356

DEFINITION

An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

PURPOSES

To permit improvement of agricultural land by preventing overflow and better use of drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments. Dikes can also be used to protect natural areas, scenic features, and archaeological sites from damage.

CONDITIONS WHERE PRACTICE APPLIES

Class I dikes are those constructed on sites where:

1. Failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways or railroads, and high value land, crops, or other improvements.
2. Unusual or complex site conditions require special construction procedures to ensure satisfactory installations.
3. Protection is needed to withstand more than 12 ft. of water above normal ground surface, exclusive of crossings of sloughs, old channels, or low areas.

Class II dikes are those constructed in highly developed and productive agricultural areas where:

1. Failure may damage isolated homes, highways or minor railroads, or cause interruption in service of relatively important public utilities.
2. The maximum design water stage against the dike is 12 ft.

Class III dikes are those constructed in rural or agricultural areas where:

1. Damage likely to occur from dike failure is minimal.
2. The maximum design water stage against the dike is 6 ft. for mineral soils and 4 ft. for organic soils. (Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

CRITERIA

In locating dikes, careful considerations shall be given to preserving natural areas, fish and wildlife habitat, woodland, and other environmental resources. If dike construction will adversely affect such values, concerned public agencies and private organizations shall be consulted about the project.

Class I Dikes

Location. Conditions to be considered in designing Class I dikes are foundation soils,

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property lines, exposure to open water, adequate outlets for gravity or pump drainage, and access for construction and maintenance. Mineral soils that will be stable in the dike embankment must be available.

Height. The design height of a dike shall be the design high water depth plus 2 ft. of freeboard or 1 ft. of freeboard plus an allowance for wave height, whichever is greater. Design elevation of high water shall be determined as follows:

1. If dike failure is likely to cause loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the stage of the 100-year-frequency flood or of the maximum flood of record, whichever is greater.
2. If dike failure is unlikely to result in loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the peak flow from the storm that will insure the desired level of protection or the 50-year frequency flood, whichever is greater.
3. If the dike will be subject to stages from more than one stream or source, the criteria indicated shall be met for the combination that causes the highest stage.
4. If the dike will be subject to tidal influence as well as streamflow, the streamflow peak shall be assumed to occur in conjunction with the mean high tide to determine the design high water depth.

The design height of the dike shall be increased by the amount needed to insure that the design top elevation is maintained after settlement. This increase shall be not less than 5 percent.

Interior drainage. If inflow from the area to be protected by the dike may result in loss of life or extensive high-value crop or property damage, provisions shall be included in the plans to provide interior protection against a 100-year-frequency hydrograph, plus base flow, and an allowance for seepage, and may include storage areas, gravity outlets, or pumping plants, alone or in combination.

If inflow from the area to be protected by the dike is unlikely to result in loss of life or extensive high-value crop or property damage, storage areas, gravity outlets, or a pumping plant, alone or in combination, shall be included in the plans and designed to handle the discharge from the drainage area based on drainage requirements established for the local area or the peak flow from the storm that will insure the desired level of protection, whichever is greater.

In sizing outlet works in combination with available storage, the minimum design storm duration for interior drainage shall be 10 days. If outlet works are designed using peak flood frequency flows without considering storage, the minimum design storm duration shall be 24 hours.

Embankment and foundation. The embankment shall be constructed of mineral soils, which when placed and compacted will result in a stable earth fill. No organic soil shall be used in the dike. Soils must have high specific gravity and be capable of being formed into an embankment of low permeability. The design of the embankment and specifications for its construction shall give due consideration to the soil materials available, foundation conditions, and requirements for resisting the action of water on the face of the dike and excessive seepage through the embankment and the foundation. The design of the embankment and the foundation requirements shall be based on the length of time and height that water will stand against the dike.

Minimum requirements for certain features of the embankment, the foundation, and borrow pits are as follows:

Minimum top width of Class I dikes shall be 10 ft. for embankment heights of 15 ft. or less and 12 ft. for heights more than 15 ft. If maintenance roads are to be established on the dike top, "turnarounds" or passing areas shall be provided, as needed. Side slopes shall be determined from a stability analysis, except that an unprotected earth slope on the waterside shall not be steeper than 4 horizontal to 1 vertical if severe wave action is anticipated.

If dikes cross old channels or have excessively porous fills or poor foundation conditions, the landside toe shall be protected by a banquette or constructed berm. Banquettes shall be used to provide construction access and added stability if channel crossings are under water or saturated during construction. Banquettes shall be designed on the basis of site investigations, laboratory analysis, and compaction methods. The finished top width of the banquettes shall not be less than the height of dike above mean ground. The finished top of the banquettes shall be not less than 1 ft. above mean ground and shall be sloped away from the dike.

A cutoff shall be used if foundation materials are sufficiently pervious to be subject to piping or undermining. The cutoff shall have a bottom width and side slopes adequate to accommodate the equipment to be used for excavation, backfill, and compaction operations. It shall be backfilled with suitable material placed and compacted as required for the earth embankment. If pervious foundations are too deep to be penetrated by a foundation cutoff, a drainage system adequate to insure stability of the dike shall be used.

Ditches and borrow pits

Landside ditches or borrow pits shall be located so the hazard of failure is not increased. Ditches for borrow pits when excavated on the water side of dikes shall be wide and shallow. Plugs, at least 15 ft. in width, shall be left in the ditches at intervals not greater than 400 ft. to form a series of unconnected basins.

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

<u>Fill Height</u>	<u>Minimum Berm Width</u>
Less than 6 ft.	12 ft.
6 ft. or more	18 ft.

A drainage system shall be used if necessary to insure the safety of a dike. Toe drains, if used, shall be located on the landside and shall have a graded sand-gravel filter designed to prevent movement of the foundation material into the drain.

Subsurface drains shall not be installed, or permitted to remain without protection, closer to the landside toe of a dike than a distance three times the design water height for the dike. If subsurface drains are to be installed or remain closer than the distance stated, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Pipes and conduits. Dikes shall be protected from scour at pump intakes and discharge locations by appropriate structural measures. A pump discharge pipe through a dike shall be installed above design high water, if feasible, or be equipped with antiseptic collars.

All conduits through a dike below the design high waterline shall be equipped with antiseptic collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed water line shall be equipped with a Dayton or a similar coupling to prevent vibration of the pumping plant being transmitted to the discharge conduits.

Class II Dikes

Design water stage. The maximum design water stage permitted is 12 ft. above normal ground level exclusive of crossings at channels, sloughs, and gullies.

If the design water depth against dikes, based on the required level of protection, exceeds 4 ft. the design shall be based on at least a 25-year-frequency flood. If this degree of protection is not feasible, the design shall approach the 25-year flood level as nearly as possible, and planned fuse plug sections and other relief measures shall be installed where appropriate.

Height. The design height of an earth dike shall be the design water depth plus a freeboard of at least 2 ft. or freeboard of 1 ft. plus an allowance for wave height, whichever is greater.

The constructed height of the dike shall be the design height plus an allowance for settlement necessary to insure that the design top elevation is maintained but shall be no less than 5 percent of the design height.

Interior drainage. Provisions must be made for adequate drainage for the area to be protected by the dike.

Cross section. The minimum requirements for the cross section of the dike where fill is compacted by hauling or special equipment shall be as follows:

Compacted Fill

Design water height (feet)	Minimum top width (feet)	Steepest side slope
0-6	6	1-1/2:1
6.1-12	8	2:1

If soils or water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and shall have minimum cross section dimensions incorporated in the fill as follows:

Dumped Fills

Design water height (feet)	Minimum top width (feet)	Steepest side slope
0-6	6	2:1
6.1-12	8	2-1/2:1

Side slopes of 3 horizontal to 1 vertical on waterside and 2:1 on landside may be used instead of 2-1/2:1 for both slopes.

The cross sections shall be strengthened or increased as required to provide additional protection against floods of long duration. The top width shall be not less than 10 ft. if a maintenance road is planned on top of the dike. "Turnarounds" or passing areas shall be provided as required on long dikes.

The side slopes shall be 3:1 or flatter on the waterside if severe wave action is expected or if a steeper slope would be unstable under rapid drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity, such as SM and ML, are used in construction.

A banquette (or constructed berm) shall reinforce the landside toe if a dike crosses an old channel or if excessively porous fill or poor foundation conditions justify such reinforcement. Such banquettes shall be used if, during construction, the channel crossing is under water or saturated. The top width of the banquette shall be equal to or greater than the fill height of the dike above the top of the banquette unless a detailed investigation and analysis show a different design is adequate.

Foundation cutoff. A cutoff shall be installed if there are layers of permeable soils or layers creating a piping hazard through the foundation at a depth less than the design water depth of the dike below natural ground level. The cutoff trench shall be of sufficient depth and width a filled with suitable soils to minimize such hazard.

Ditches and borrow pits. Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill height	Minimum berm width
Less than 6 ft.	10 ft.
6 ft. or more	15 ft.

A landside ditch or borrow pit shall be far enough away from the dike to minimize any hazard to the dike because of piping through the foundation.

For dikes having a design water depth of more than 5 ft., the landside ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design waterline with the waterside of the dike and the landside toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

Pipes and conduits. The dike shall be protected from scour at a pump intake and discharge by appropriate structural measures. A pump discharge pipe through the dike shall be installed above design high water, if feasible, or else equipped with antiseptic collars.

All conduits through the dike below the design high waterline shall be equipped with anticeptic

collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed waterline shall be equipped with a Dayton or a similar coupling to prevent vibrations of the pumping plant being transmitted to the discharge conduits.

Drains. Drains shall be used where necessary to insure safety of dikes and shall be located on the landside, have a graded sandgravel filter, and be designed and installed in accordance with NRCS standards for such drains. Field subsurface drains shall not be installed or permitted to remain without protection closer to the landside toe of a dike than a distance three times the design water height for the dike. If such drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sandgravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Class III Dikes

The design criteria shall be based on site conditions for mineral or organic soil as applicable.

Top width. Minimum top width is 4 ft.

Side slopes. Minimum side slope is 1:1.

Freeboard. The minimum freeboard is 1 ft. plus wave height. The constructed height shall be increased by the amount necessary to insure that the settled top is at design elevation but not less than 5 percent.

Foundation cutoff. A cutoff shall be installed if necessary to insure dike stability.

Ditches and borrow pits

Minimum berm widths between the toe and the dike and the edge of the excavated channel or borrow shall be two times the depth of the ditch but not less than 8 ft.

CONSIDERATIONS

Dikes should be part of the treatment needed to protect the soil, water, plant, animal and air resources. The management system must be planned to prevent excessive maintenance and operation problems.

Effects on water quantity and quality shall be considered. This practice is used to prevent water flowing onto an area, or it is used to prevent water flowing off an area. When water is prevented from flowing on an area by confining the channel on both sides, the time for the peak flow may be increased. It also may increase the headwater elevation in the channel, often moving the area of flooding into a different reach of the channel. When a dike is placed on only one side of a channel, water is forced to the opposite side and the depth may be increased. Where dikes are used to control water and retain it within a specific area, there may be an increase of available water within the containment area. Where dikes are used to prevent water from flooding on the floodplain, the pollution dispersion effect created by the flood plain wetlands is decreased. The sediment, sediment-attached, and soluble materials being transported by the water are carried farther downstream. The final deposition point of these materials must be investigated on each site. Where dikes are used to retain runoff on the flood plain or in wetlands, the pollution dispersion effects of these areas may be enhanced. Retention of the water by the dike may cause sediment and attached substances to be deposited, and the quality of the water flowing into the stream from this area will be improved.

Special attention shall be given to maintaining the improving visual resources and habitat for wildlife where applicable. The landowner/user shall be advised if wetlands will be affected and USDA-NRCS wetland policy will apply. All work planned shall be in compliance with General Manual Title 450-GM, Part 405, Subpart A, Compliance With Federal, State, and Local Laws and Regulations. If archaeological and historic properties are encountered, the USDA-NRCS policy in General Manual Title 420-GM, Part 401 shall be followed.

Water Quantity

1. Effects upon components of the water budget, especially on volumes and rates of runoff, infiltration, evaporation and transpiration.
2. Potential for changes in rates of plant growth and transpiration because of changes in the volume of soil water.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effects on the rate of volume of downstream flow to prohibit undesirable environmental, social or economic effects.

Water Quality

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects on the movement of dissolved substances to ground water.
3. Short-term construction and maintenance related effects on the quality of water resources.
4. Potential for earth moving to uncover or redistribute toxic materials such as saline soils and make them available for undesirable effects on water or vegetation.
5. Effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.
6. Effects on wetlands or water-related wildlife habitats.
7. Effects on the visual quality of water resources.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing dikes shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction specifications

General. Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution will be minimized and held within acceptable limits. Construction methods that enhance wildlife will be used where practical. Trees, stumps, and brush removed from the construction area may be piled for wildlife habitat when approved by the landowner/user.

The completed job shall present a workmanlike appearance and conform to the line, grades and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used.

Site preparation. Clearing shall consist of felling and disposing of trees, snags, logs, brush, stumps, and rubbish from the designated areas on the plans. Special attention shall be given to protecting and maintaining key shade, food and den trees and visual resources. Trees to be left standing and uninjured within the clearing limits shall be marked. Removal of any trees and brush shall be done in such a manner as to avoid damage to other trees and property outside the areas to be occupied by dike and borrow pits as feasible.

All trees, stumps, brush, and similar materials are to be removed from the site or disposed of in such a way as to have the least detrimental effect on the environment. Material that is buried shall be covered with a minimum of 2 feet of earthfill plus the specified depth of topsoil in designated areas.

Foundation preparation class I and II dikes. The foundation area shall be cleared of all trees, stumps, roots, brush, boulders, sod and debris. All channel banks and sharp breaks shall be sloped no steeper than 1:1. Topsoil, which is high in organic matter, shall be removed. The surface of the foundation shall be thoroughly scarified before placement of the embankment material.

The cutoff trench, where used, shall be excavated to lines and grades as shown on the plans. It

shall be backfilled with suitable material in a manner as specified for earth embankments. The necessary compaction shall be obtained by using equipment adapted to site conditions. The trench shall be kept free of standing water during backfill operations. Material from the cutoff trench may be placed within the dike section if suitable.

Foundation preparation class III dike. The foundation area shall be cleared of trees, brush, other vegetation, and debris. Trees and stumps shall be cut at approximate ground level. The surface shall be scarified where needed to obtain a satisfactory bond with the dike.

Conduit installation class I and II dikes. All conduits through a dike shall be placed on a firm foundation to the lines and grades shown on the plans. Selected backfill material shall be placed in layers around the conduit and their component parts and each successive layer shall be thoroughly compacted.

Conduit installation class III dike. Earth fill around conduits through the dike shall be thoroughly tamped.

Embankment construction class I dike. The material placed in the fill shall be free of all sod, roots, frozen soil, stones over 6 inches in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation and the fill shall be brought up in approximately horizontal layers of thickness. The construction equipment shall be operated over the area of each layer in the way that will result in the required compaction. Special equipment shall be used when the required compaction cannot be obtained without it. The distribution and gradation of material throughout the fill shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from surrounding material. Where it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the waterside and center portions of the fill.

Embankment construction class II dike. The embankment material may be obtained from a selected borrow area or from a channel. In the

construction of borrow trenches on the water side of the dike, an unexcavated plug at least 25 feet wide shall be left at intervals not to exceed 1320 feet.

The fill material shall be free of organic matter and other objectionable material. Placing and spreading of fill shall begin on the lowest part of the working area and continue in horizontal layers of approximately uniform thickness, preferably 6 inches thick but not more than 18 inches thick, depending on the equipment used. Where the borrow yields material of varying texture and gradation, the more impervious material shall be placed toward the water side of the dike. The construction equipment shall be operated over each layer in a manner to break up large clods and obtain compaction.

Fill material shall be moist but not too wet for equipment operations and shaping. Water shall be added to the fill material where it is too dry to permit compaction.

Dumped fill, where used, shall be placed in layers or deposited in a manner suitable to the equipment used and the material excavated. Shaping shall be done so as to break up lumps and clods of earth. Excessively wet material shall be placed to permit free drainage and shaped after it has drained. When the fill slumps due to wetness, the dike shall be constructed in stages.

Embankment construction class III dike. The spoil shall be placed to the height required for the dike and where needed to obtain stability or adequate compaction, it shall be raised in stages.

Materials. Corrugated metal pipe shall conform to the requirements of Federal Specifications WW-P-402 or WW-P-405, as appropriate. Other pipe materials shall conform to appropriate specifications. Antiseptic collars shall be of materials compatible with that of the pipe and shall be installed so that they are watertight. The pipe shall be installed according to the manufacturer's instructions. It shall be firmly and uniformly bedded throughout its length and shall be installed to the line and grade shown on the drawings.

The mix design and testing of concrete shall be consistent with the size and requirements of the

job. Mix requirements or necessary strength shall be specified. The type of cement, air entrainment, slump, aggregate, or other properties shall be specified as necessary. All concrete is to consist of a workable mix that can be placed and finished in an acceptable manner. Necessary curing shall be specified. Reinforcing steel shall be placed as indicated on the plans and shall be held securely in place during concrete placement. Subgrades and forms shall be installed to line and grade, and the forms shall be mortartight and unyielding as the concrete is placed.

Other materials used in construction of a dike will be as specified on the drawings or as otherwise specified.

Finish and cleanup. Construction areas will be finished in a relatively smooth condition ready for seeding. All rocks 3 inches in diameter or larger and roots shall be removed from the areas.

Construction Tolerances. The following are guidelines for dike construction:

Elevation (includes overfill)	
Fills over 4.0 ft. -	+1.0 foot
Above grade	or 10% of height, whichever is less
Fills under 4.0 ft. -	
Above grade	+0.4 foot
All fills-below grade	-0.1 foot
Top width	+0.5 foot
Side slope Elevations	
Above grade*	+1.0 foot
Below grade*	-0.5 foot
Pipe conduits	
Grade (no reverse grades)	+0.2 foot
Crest (riser elevation)	+0.1 foot
Horizontal alignment	+1.0 foot

*All plus and minus variations for side slopes measured vertically.

Vegetative establishment. A protective cover of vegetation shall be established on all exposed surfaces of the dike, borrow area and disturbed areas if soil and climatic conditions permit. If soil or other conditions preclude the use of vegetation and protection is needed, nonvegetative cover such as mulches, gravel or riprap may be used. In some places, temporary vegetation may be used until permanent

vegetation can be established. Trees and shrubs should be established where practical. Disturbed areas are to be final graded and seeded or planted to trees as soon as possible after exposure. Use daily seeding where practical. Planned trees and shrubs shall be established according to Technical Guide Specification 612, Tree/Shrub Establishment. The dike shall be fenced, if necessary, to protect the vegetation.

Gullied and uneven areas should be smoothed before attempting to prepare seedbed.

If needed, apply lime to raise the pH to the level desired for species of vegetation being seeded.

Fertilize according to soil tests or at a minimum rate of 1000 lbs. Of 12-12-12 fertilizer or its equivalent per acre as soon as the measure has been constructed within the seeding periods. Apply 150 lbs. per acre of ammonium nitrate 6-8 weeks after seeding on soils low in organic matter and fertility unless this time frame extends into an inactive growing period. In this event, the additional fertilizer should be applied during the next active growing period.

Work the fertilizer and lime into the soil to a depth of 2-3 inches with a harrow or disk. Prepare a firm seedbed with a cultipacker or cultipacker type seeder.

Seed one of the following grass mixtures during the preferred seeding periods of March 1 to May 10 or August 10 to September 30.

When construction is completed between May 11 and August 9, a temporary cover crop should be established using on the following:

Species	Minimum Rates
Wheat	150# per acre
Rye	150# per acre
Spring Oats	100# per acre
Annual Rye grass	20 # per acre
Corn	150-300# per acre

After August 10, temporary cover should be removed or incorporated, fertilizer applied, seedbed prepared and permanent seeding done in a normal manner.

When construction is completed between September 30 and March 1, prepare seedbed, fertilize and mulch according to recommendations. Seed should be applied over mulch sometime between December 1 and March 1. When this seeding method is used, seeding rates should be increased 50%.

On critical sites, mulch with 1 1/2 to 2 tons straw per acre. Anchor the mulch with asphalt spray, netting or a mulch anchoring tool. In areas such as sharp breaks in embankment and abutment contact areas, excessive velocities could cause bank scour, paper netting, jute netting, rock lining, erosion control blankets or sod should be used.

Dike Seed Mixtures

Species	Seeding Rate (PLS)		Suitable pH	Site Suitability		
	lbs/acre	lbs/1000 ft ²		Droughty	Well Drained	Wet
1. Tall fescue	20	0.5	5.0-8.0	2	1	
Smooth brome	20	0.5				
2. Reed canarygrass	18	0.4	3.5-7.5	2	1	1
3. Kentucky bluegrass	20	0.5	5.8-7.5	2	1	
Creeping red fescue	20	0.5				
4. Tall Fescue	35	0.8	5.5-8.3	2	1	2

Note: Site Suitability -- 1 = Preferred 2 = Acceptable

PLS = Pure Live Seed

Mixture 3 may be used through urban or similar areas where lower growing vegetation is desired and close mowing will be practiced; also, withstands shade better.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain capacity and vegetative cover. Items to consider are:

1. Do not graze protected area of dike.
2. Fertilize to maintain a vigorous vegetative cover in protected area. Caution should be used with fertilization to maintain water quality.
3. Mulch, spray or chop out undesirable vegetation periodically to prevent growth of large woody stemmed weeds, water plants such as cattails or trees (such as willows) from embankment and spillway areas.
4. Promptly repair eroded areas.
5. Promptly remove any burrowing rodents that may invade area of dike.
6. Reestablish vegetative cover immediately where scour erosion has removed established seeding.
7. Keep open all spillways and remove trash that may accumulate around entrance.
8. Periodically inspect area for any new maintenance items and if any observed take immediate action to protect from further damage or deterioration.

